ADDRESSING RISING DEMAND FOR COOLING IN INDIA WITH COOL ROOFS

Summary

As India's urbanization accelerates and climate change intensifies, cities across the country face an unprecedented challenge in adapting to a warmer planet. Keeping people in India cool and reducing heat-related health problems is an urgent need; though air conditioning (A/C) is an important climate adaptation in India, this cooling technology remains accessible to only about 6% of housing units.[1] In 2019, extreme heat caused an estimated 46,600 early deaths in India – but air conditioning can provide lifesaving relief.[2] India's demand for air conditioning is expected to increase dramatically to help counter worsening heat, and if this increasing cooling energy demand is met by electricity supplied by burning fossil fuels, it will further exacerbate climate change and related stressors, including hazardous air pollution that currently threatens much of the country.[3] Scalable landcover interventions such as cool roofs that reduce heat accumulation in urban areas (Figure 1) can help reduce indoor temperatures[4] and partially compensate for rising cooling energy demand in buildings.[5]

Expanding cool roofs in Ahmedabad, India from 5% of residential roof area to 20% by 2030 could deliver energy savings that more than offset additional cooling energy demand linked to climate warming.

Credit: NRDC and AMC

Figure 1: Slums being painted with solar reflective paint by Ahmedabad Municipal Corporation (AMC) in 2020 (top). Former Ahmedabad Mayor Gautam Shah painting a cool roof with white paint in Ahmedabad, India, in 2017 (bottom).

Cool roofs are a simple and cost-effective solution that can help partially offset rising cooling energy demand in India linked to climate change, among other factors.[6] These roof modifications help building surfaces to reflect sunlight and thereby absorb less heat. Many cities around the world are already deploying cool roofs to address extreme heat, and researchers have identified a number of health, economic, and environmental benefits.[7,8] New research led by a team of local energy and health experts, published in a peer-reviewed scientific journal, provides estimates of year 2030 cooling energy demand savings achievable through expanded cool roof installations for an Indian city for the first time.[9] Even as population growth, economic expansion, and climate warming drive increasing demand for cooling in India over the coming years, this new analysis indicates that ambitious expansion of cool roof solutions can help the country to reduce strain on the electrical grid by reducing demand for energy to power cooling.

Intensifying Cooling Energy Needs in Indian Cities

Climate change is already worsening the frequency and intensity of heatwaves[10] and heat stress[11] around the world. In India, temperature records show a 17 percent increase in the number of extremely hot days (34.2-40.2 °C, or 93.6-104.4 °F) observed between 1981 and 2010 and a 76 percent increase in the number of people exposed to extreme heat over the same period.[12] Extreme heat is a particular threat in fast-growing urban areas due to the combination of heat-trapping paved surfaces like concrete and asphalt, tall buildings, heat-generating human activities, and absence of vegetation—factors that act together to trap heat.[13] As they increase in frequency, heatwaves in India are leading to life threatening consequences: recent estimates show a 55% increase in the annual number of deaths of adults over 65 years old attributable to heat exposure, comparing 2017-2021 to a 2000-2004 baseline.[14] During the summer of 2022, India experienced weeks of searing heat that were made at least 30 times more likely because of planet-warming greenhouse gas pollution from burning fossil fuels.[15]

Improving Access to Cooling Solutions

Along with intensifying heat-related hazards to human health, India is also facing a growing cooling access challenge. According to estimates published in the India Cooling Action Plan (ICAP), countrywide cooling demand will grow by a factor of eight in 2037–2038 compared to a 2017–2018 baseline.[16] Much of that growth will be driven by increased demand for space cooling (Figure 2): air conditioner ownership is predicted to more than double by 2037.

If the electricity to power cooling is supplied by fossil fuels (coal, oil, and gas), this climate adaptation response can worsen ambient air pollution and emit carbon dioxide pollution that worsens climate change itself.[17] While improving access to cooling technology such as air conditioning remains a critical step, equally important will be the expansion of landcover-based cooling strategies. These technologies can help to reduce the need for energy-intensive A/C use to begin with and are urgently needed in India and in other heat-stressed countries worldwide.

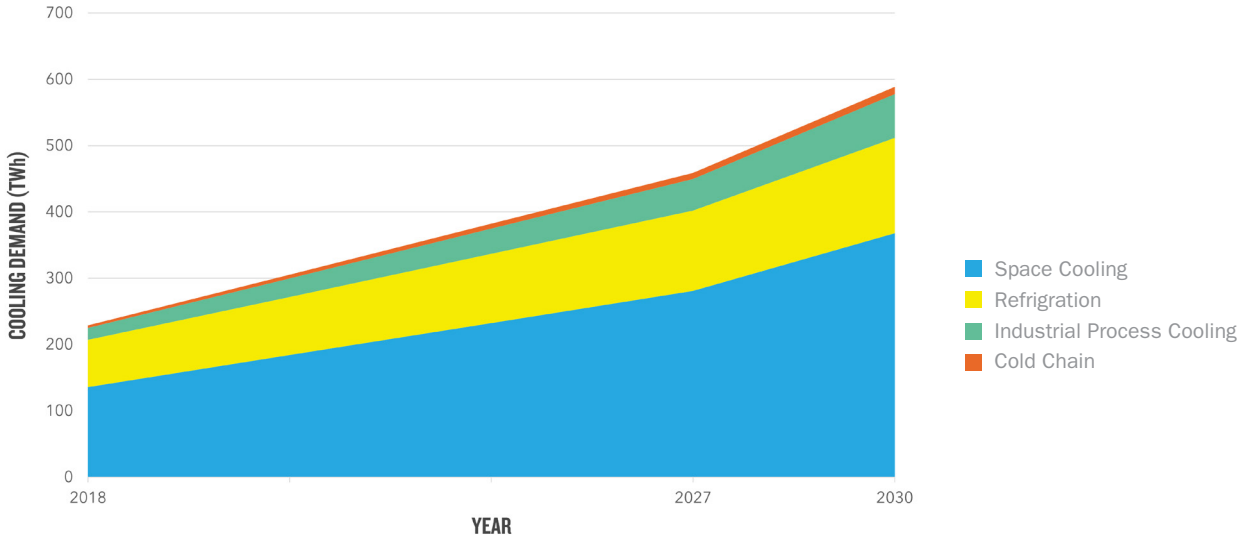

Figure 2: India's Cooling Action Plan indicates that demand for cooling will grow eightfold by 2037–2038 compared to 2017–2018
(Credit: Susan Lee/NRDC, adapted from Indian Ministry of Environment, Forests, and Climate Change data).[16]

HOW DOES A COOL ROOF WORK?

Roofs are an important component of the overall building surface, and roof composition has a direct impact on a building's energy needs and its occupants' thermal comfort. Cool roofs function primarily by reflecting more sunlight incident on the roof back to the atmosphere than a regular roof surface. As a result, the roof stays cooler throughout the day, keeping buildings cooler and more comfortable.

These roofs are prepared, covered or coated with materials that have special characteristics (high reflectivity and high emissivity, are measured by their solar reflective index (SRI)). The two most important factors that determine the effectiveness of a surface to function as a cool roof are its ability to reflect solar energy (known as solar reflectance or albedo) and emit absorbed energy (thermal emittance). Most dark roofs reflect no more than 30 percent of incoming sunlight (i.e., these surfaces have a solar reflectance of 0.3 or less), while a new white roof reflects about 70 to 80 percent of sunlight (solar reflectance of 0.7 to 0.8).[8] Cool roofs provide health and environmental benefits for households, buildings and wider communities. If installed over a large area, cool roofs can help to reduce the urban heat island effect[13] by lowering ambient air temperatures; some research indicates that cool roof measures can also reduce air pollution on an urban scale.[20,22]

Many cities around the world are already deploying cool roofs, and researchers have identified a number of associated health, economic, and environmental benefits.[18,19]

Despite the potential for passive cooling interventions such as cool roofs to serve as a cost-effective climate change adaptation strategy and with cool roofs already installed in some Indian cities, there has to date been little analysis of their potential to reduce energy demand to cool buildings at the city scale.[20] As Indian cities continue to grow and municipal leaders strengthen Heat Action Plans[21] to manage extreme heat risks, a clearer understanding of the energy benefits of cool roofs can help to motivate stronger and more coordinated cool roof deployment at larger regional and national scales.[22]

New Study Quantifies Energy Savings from Cool Roofs

A new peer-reviewed research study[23] led by a team of experts at the Gujarat Energy Research and Management Institute (GERMI), Indian Institute of Public Health-Gandhinagar (IIPH-G), and Natural Resources Defense Council (NRDC), published in the scientific journal *Mitigation and Adaptation Strategies for Global Change*, provides, for the first time, city-level estimates of the cooling energy demand reductions for the city of Ahmedabad (Figure 3), achievable through cool roof interventions in the context of climate change-driven warming by the year 2030.

The analysis accounted for future population growth and economic expansion in the western city of Ahmedabad (population 8.5 million in 2018), along with anticipated climate change-driven warming to project citywide cooling demand. Pairing energy projections with modeled estimates of energy savings achievable through differing levels of cool roof installations, researchers quantified the degree to which cool roof interventions could help to moderate future cooling energy demand at the city level.

With the current, limited implementation of cool roofs across India, understanding their local impacts is key to helping expand their role in cooling cities across the country. This research found that though city-level cooling energy demand is set to grow dramatically, expanding cool roofs from today's 5% of available residential roof area to 20% by the year 2030 (i.e. covering just one

Credit: Mahila Housing Trust

Figure 3: A woman in Ahmedabad city painting her home roof with solar reflective paint.

in five residential buildings) would achieve cooling energy savings that exceed the additional cooling energy demand linked to climate warming.

Climate change-fueled warming is expected to add 0.17 terawatt-hours (TWh) of cooling demand to Ahmedabad in 2030 (compared to a 2018 baseline), but this modeling estimated that the city could cut 0.21 TWh in cooling demand through expanded cool roof implementation.[24] Ahmedabad currently supplies its energy from a combination of burning fossil fuels (including coal) and renewable energy sources.[25] For Ahmedabad, reducing energy demand by 0.21 TWh would be equivalent to avoiding 191,000 metric tons of carbon dioxide pollution, or the emissions from burning 21.5 million gallons of gasoline.[26]

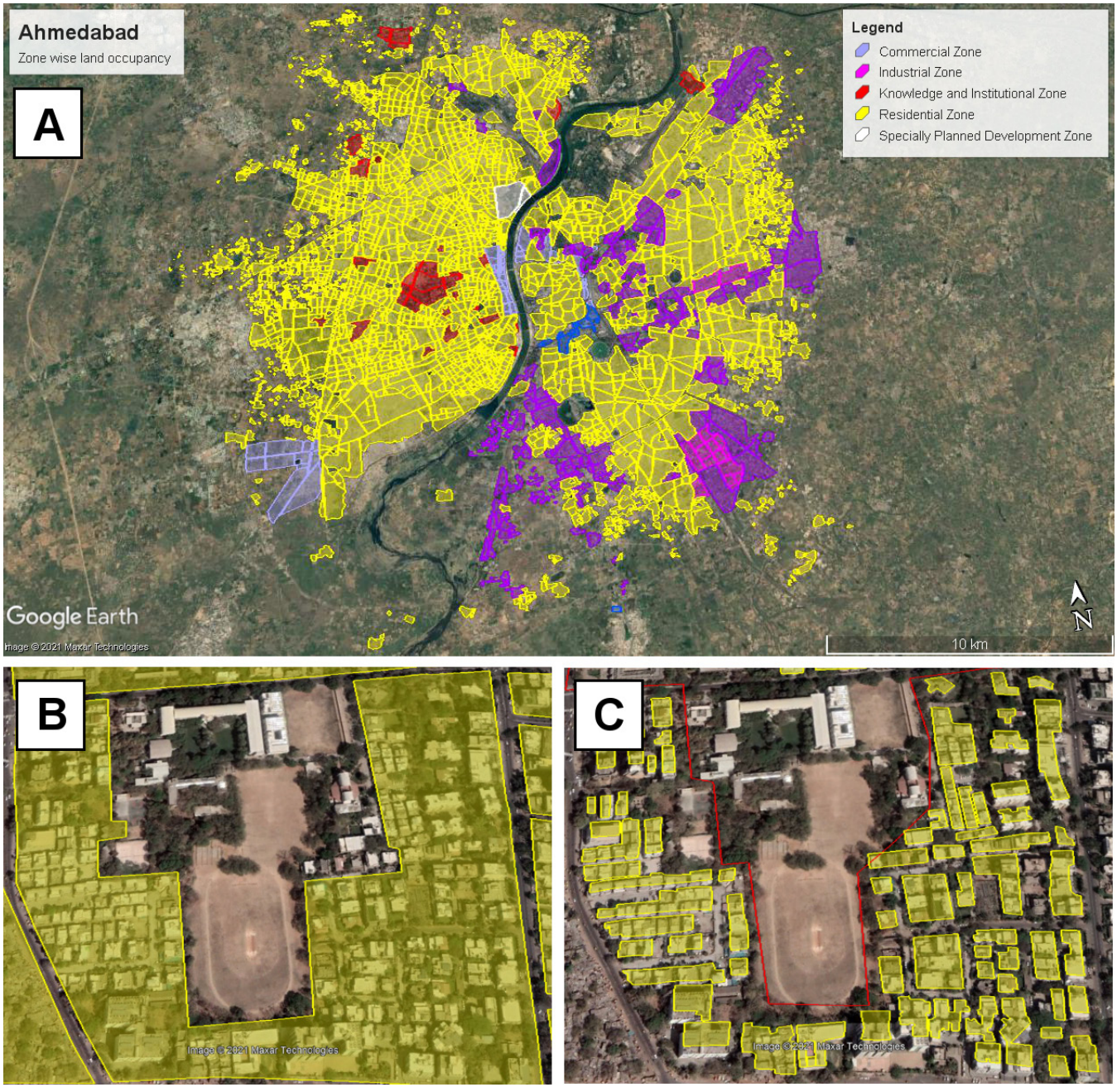

Figure 4: The research team utilized Google Earth satellite imagery and city maps to estimate the extent of residential zones (panels A and B) and available residential roof area (panel C) in Ahmedabad to understand the energy savings benefits of cool roofs (Credit: Joshi et al., 2022).[6]

This research shows that cool roofs can be an effective tool to address rising cooling energy demand as urban heat intensifies. With air conditioning still unaffordable for many heat-vulnerable populations in India, cool roofs could help make urban life—even in a hotter world—safer and more comfortable, with far-reaching consequences for public health.[27]

Advancing Methods to Quantify Cool Roof Benefits

The analysis in the study deployed a transparent, adaptable approach that could enable other Indian cities to analyze the energy savings achievable through expanded cool roof installations. Using publicly available Google Earth satellite data (Figure 4), researchers mapped out the total roof area available for modification in Ahmedabad, and overlaid the city map of municipal zones to categorize modifiable roof area by building type.

The research team then developed a dynamic analysis tool that integrated data on economic and population growth, urban expansion, and climate warming; and projected cool roof-related cooling energy savings (based on ICAP cooling demand projections localized to Ahmedabad, and prior cool roof and energy studies in India).[28] The spreadsheet tool and underlying data used for this study are publicly available,[29] and the analysis for Ahmedabad can be easily modified and implemented by any municipal authority to estimate the scale of cooling energy demand savings achievable through future cool roof expansions at the city level.

Keeping Cool in a Warmer World

As this new study shows, cool roofs can play a role in helping Indian cities to respond to rapidly rising cooling energy demand. To make them an option for every urban household, municipal policies can incorporate them in their plans to build heat resilience. With a price ranging 25-100 rupees per square meter[30] (depending on the material used), cool roofs are one of the most affordable cooling solutions available today. For people living in urban slum communities and structures built with heat-trapping, low-ventilation roof materials, cool roofs can help to keep indoor temperatures lower[31] and protect people's health and wellbeing.

With stronger government support, millions of Indian households can benefit from cool roofs in the coming decades. Leaders can plan for cool roofs in building decarbonization efforts—for example, by mandating cool roof installations in state Energy Conservation Building Codes.[32] Municipal authorities can use local Heat Action Plans to recognize the benefits of cool roofs and expand their implementation across urban spaces. Moreover, cool roofs can play a role as India works to build more affordable, resilient housing with programs like Pradhan Mantri Awas Yojana[33] (the Prime Minister's Housing Scheme), and the International Coalition for Disaster-Resilient Infrastructure. **As India's cities reckon with their role at the frontlines of the climate crisis, cool roofs are a critical tool for helping people to cope with a warmer world.**

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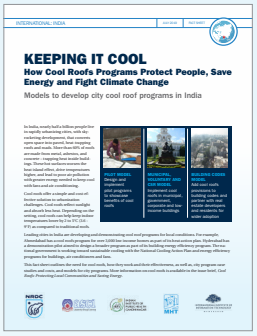
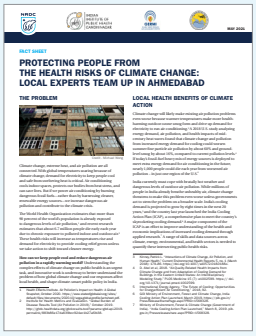
Highlighted Reports

Climate change and 2030 Cooling Demand in Ahmedabad, India: Opportunities for Expansion of Renewable Energy and Cool Roofs



KEEPING IT COOL: How cool roofs program, protect people, saver energy and fight climate change

Frequently Asked Questions (FAQs): COOL ROOFS



Identifying the Health Benefits of Addressing Climate Change in Ahmedabad, India